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THE MASSES OF THE STARS

By SERGEI GAPOSCHKIN

LET us begin with the society of old Greece, a people that showed an indisputable ability to think scientifically; and let us ask ourselves what kind of idea they had concerning the masses of the heavenly bodies. We need not hesitate to say that they had none, or if they had, we cannot trace it among their writings. Perhaps it is no wonder that they did not speculate about the masses of the stars, for they thought in purely geometrical form. This geometrical tendency can be traced not only in their astronomical thoughts—their conception of the shape and size of the heavenly bodies was in many ways identical with our own—but also, to an even stronger degree, in the innumerable pieces of sculpture and architecture that have come down to us.

There was one man among them, indeed, whom we might expect to have had some idea about stellar masses: Archimedes, the great physicist of ancient Greece; for it is the physicist, not the mathematician, who enquires concerning masses. But though, in a famous letter, he tried to count the number of grains of sand in his enormous but finite universe, yet he has left no indication that he had any idea concerning our problem.

The blossom of Greek thought began to decline, and it was not long before Western Europe entered upon the miserable centuries during which ignorance was the rival of the Roman rule. Seventeen hundred years elapsed, and a physical conception of the Universe began again to penetrate the minds of scholars in Western Europe.

After the establishment of the "Laws of Newton" (1686) and the "Cavendish experiment" (1782) the first step in the determination of the stellar masses was taken: by means of the gravitational

constant, the masses of the planets and of the sun (the nearest star to us) were successfully determined.

It is, however, only during the last fifty years that systematic observations have been made of the masses of the stars in general; the discovery and investigation of the double stars has extended the applications of the Newtonian laws far beyond the limits of our solar system.

There are two independent sources for the determination of stellar masses: double stars (visual binaries, or spectroscopic binaries that are at the same time eclipsing variables); and the relativity effect in a gravitational field. The author has been principally concerned with the former source, from which the results given here are derived.

Visual Binaries

There are two very recent investigations of the masses of visual binaries, made respectively by Parenago[1] on "The Mass-luminosity Relation," and by Kuiper[2] on "The Empirical Mass-luminosity Relation". Both authors discuss first visual binaries, then eclipsing variables. In respect to the visual binaries they do not differ essentially: Parenago's list contains fifty systems, Kuiper's only thirty, but Parenago's additional stars are of low weight, and do not affect the results appreciably.

Twenty-one stars, common to the two lists, may be regarded as the most reliable. In forming means for these (Table I) the results of the two authors have been given equal weights. The three groups into which the material is divided correspond to the (combined) weights: 50 and over, 20-49, and 20 and below. Only the observational results are given. We must note that the three systems, Capella, Sirius, and α Centauri, overweight the whole material. Most of the masses are near that of the Sun, the extreme range being from 0.17 to 4.27 solar masses. Only six of the stellar components are heavier than the sun.

Eclipsing Variables

The eclipsing binaries supply us with material that is both superior and inferior to that offered by visual binaries. The hottest

[1]Astr. Journ. of Soviet Union, v. 14, p. 33, 1937.
[2]Ap. J. v. 88, p. 472, 1938.

TABLE I.—Masses of Visual Binaries

Star	Spectra 1	Spectra 2	Visual Absolute Magnitude 1	Visual Absolute Magnitude 2	Logarithm of masses 1	Logarithm of masses 2	Masses (⊙ = 1) 1	Masses (⊙ = 1) 2
I Class								
αAur	G2.5	F7	−0.2	−0.1	0.63	0.52	4.27⊙	3.31⊙
αCMa	A0	A8	1.3	11.2	0.38	−0.02	2.40	0.96
αCMi	F3	—	2.8	14.5	0 16	−0.33	1.45	0.47
ξUMa	F9	G0	5.2	5.6	−0.04	−0.11	0.91	0.78
αCen	G4	K3	4.6	5.9	0.04	−0 05	1.10	0.89
ξBoo	G6.5	K5	5.6	7.5	−0.08	−0.12	0.83	0.76
70 Oph	K1	K5	5.7	7.4	−0.05	−0.14	0.89	0.72
Kr. 60	M3.5	M5.5	11.8	13.4	−0.60	−0.78	0.25	0.17
II Class								
ηCas	F9	K7.5	4.9	8.9	−0.08	−0.40	0.83	0.40
o_2EriBC	B9	M5e	11.1	12.7	−0.37	−0.66	0.43	0.22
ζUMa A	A2	A2	1.5	1.5	0.42	0.42	2.63	2.63
ξHer	G0.5	K5	3.2	6.4	−0.04	−0.20	0.91	0.63
BD 8°4352	M3.5	—	10.8	—	−0.46	—	0.35	—
β416	K5	(M2)	6.9	8.8	−0.21	−0.33	0.62	0.47
μHerBC	M3.5	(M4)	10.6	10.9	−0.34	−0.34	0.46	0.46
δEqu	F5.5	F5.5	4.2	4.3	+0.10	0.09	1.26	1.23
III Class								
αGem	A1	F5.5	1.3	2.1	0.38	0.29	2.40	1.95
9Pup	G1.5	G3	4.8	5.3	0.11	0.07	1.29	1.27
γVir	F0	F0	3.4	3.4	0.09	0.09	1.23	1.23
44Boo	G1	G4	5.0	6.2	−0.19	−0.19	0.65	0.65
85Peg	G2.5	M3:	5.6	9.9	−0.16	−0.39	0.63	0.41

and the largest stars (O, B and K, M) are very massive, and the eclipsing stars are especially rich in the former. On the other hand, the parallaxes of the majority of eclipsing stars of known mass are ill determined, excepting for such systems as YY Geminorum, i Bootis, β Aurigae, and μ Scorpii. The absolute magnitudes of eclipsing systems therefore depend to a high degree upon the temperature scale, which is the most vulnerable point in the data for this group of stars. A similar problem is encountered in obtaining the radii of visual binaries.

Table II contains the masses of thirty-seven eclipsing stars

TABLE II.—Masses of Eclipsing Variables

Star	Spectra		Logarithm of masses		Masses ($\odot$=1)	
	1	2	1	2	1	2
I Class						
δ Aql	B8	B8	0.79	0.71	6.19	5.14
TT Aur	B4	B4	0.83	0.72	6.75	5.26
WW Aur	A5	A5	0.34	0.28	2.20	1.91
AR Aur	A0	A0	0.43	0.40	2.68	2.52
β Aur	A1	A1	0.38	0.37	2.40	2.36
ζ Aur	K5	B9	1.22	0.98	16.5	9.60
i Boo	G2	G2	−0.19	−0.19	0.64	0.64
RS CVn	F4	G8	0.27	0.24	1.85	1.74
TV Cas	B8	B9	0.26	0.00	1.83	1.00
UW CMa	O8	O8	1.61	1.49	40.3	30.8
Y Cyg	B0	B0	1.24	1.24	17.5	17.5
MR Cyg	A0	A0	0.48	0.41	3.03	2.59
WW Dra	G5	G8	0.53	0.38	3.40	2.40
YY Gem	K8	K8	−0.20	−0.24	0.63	0.57
Z Her	F3	F3	0.20	0.11	1.60	1.30
RX Her	A0	A0	0.34	0.28	2.20	1.90
TX Her	A3	A3	0.32	0.25	2.06	1.77
RT Lac	G5	K1	0.70	0.00	5.00	1.00
AR Lac	G5	G7	0.15	0.15	1.42	1.42
CM Lac	A2	A2	0.30	0.18	2.00	1.50
U Oph	B7	B7	0.73	0.67	5.36	4.71
WZ Oph	G0	G0	0.15	0.15	1.42	1.42
V Pup	B1	B3	1.33	1.21	21.2	16.3
W UMa	F9	F9	−0.12	−0.27	0.75	0.54
TX UMa	B9	A3	0.49	−0.03	3.07	0.93
Z Vul	B3	B3	0.73	0.37	5.34	2 36
II Class						
S Ant	A8	A8	−0.12	−0.38	0.75	0.42
AO Cas	O8.5	O8.5	1.56	1.53	36.3	33.6
VV Cep	M2	B9	1.65	1.55	44.5	35.6
AH Cep	B1	B1	1.16	1.10	14.6	12.7
U Cr B	B5	B9	0.72	0.30	5.3	2.0
u Her	B3	B3	0.88	0.46	7.52	2.87
AG Per	B3	B3	0.72	0.66	5.2	4.6
RS Vul	B8	B9	0.72	0.21	5.26	1.64
μ Sco	B3	B3	1.09	1.09	12.4	12.4
B4520	B0	(B0)	1 63	1.59	42.5	39.1

compiled by the author from original sources. The material has been divided into two classes in respect to reliability. The masses are well determined for all the stars excepting VV Cephei and Boss 4520; the orbital velocities of the components are accurately known for all of them. We have placed in the second group those stars for which the masses are uncertain as a result of uncertainty of the inclination derived from the light curve.

TABLE III.—Spectrum—Mass Relation for 223 Stars*

Spectrum	Logarithm of Mass		Logarithm of Mass-Ratio		Number of Stars
O8.9	1.48	± 0.04	−0.12	±0.03	7
B0.8	1.28	2	−0 27	4	8
B3.1	1.02	2	−0.23	3	15
B5	0.85	2	−0 13	3	10
B8.2	0.66	5	−0.32	3	15
A0	0.53	2	−0.35	4	62
A2.9	0.45	3	−0.38	2	30
A6	0.41	2	−0.28	2	21
F0	0.29	8	−0 20	4	9
F2.5	0.24	4	−0.21	4	7
F5	0.22	3	−0.23	4	6
G0	0.09	4	−0.13	2	10
G0	0.82	40	....	–	3
G5	−0.10	5	−0.25	5	11
K0	−0.16	5	−0.18	2	4
K5	−0.24+)				
M0	−0.42+)				

*Taken from the diagram with consideration of visual binaries.

DISCUSSION

The eclipsing variables supply seventy-four determinations of stellar mass, the visual binaries, forty-one. Between them, these two groups of double stars display a large variety of mass.

There can be no doubt that the mass of a star is one of its most important characteristics. It is therefore natural to attempt to correlate the mass of a star with other physical quantities. In order to increase the amount of material available, the author has recently completed a discussion of the masses of the components

of 272 eclipsing systems.[3] Of the 544 single components there are but 223 that are reliable enough to be used.

The relation between spectrum and mass is shown by Figure 1 and Table III: the masses change rapidly with spectrum for classes earlier than B4, but the change is slower for the later classes.

TABLE IV.—Mass-Radius Relation for 223 Stars

Logarithm of Mass		Logarithm of Radius		Number of Stars
−0.41	±0.05	−0.33	±0.07	2
−0.08	1	−0.12	2	13
+0.12	1	+0.14	2	21
0.40	1	0.30	1	61
0.62	1	0.52	1	76
0.86	2	0.73	2	26
1.12	1	0.89	3	16
1.38	2	1.22	3	5
1.59	5	1.33	3	3

TABLE IVa.—Large Stars

Logarithm of Radius		Number of Stars
+0.91	± 0.02	7
1.16	4	7
1.80	2	2
2.47	–	1
2.88	30	2

The relation between mass and radius, for 223 eclipsing variables, is shown in Figure 2 and Table IV. Mean radii are calculated for various intervals of mass. The straight lines correspond to the following relations:

Main Sequence: $\log R = 0.82 \log \mu$

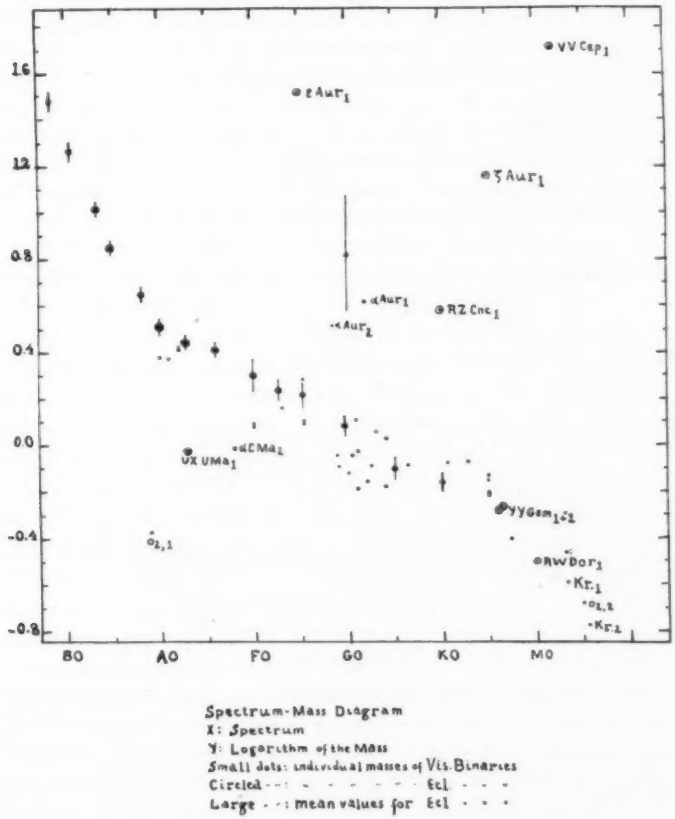
Stars with $R > 10\,\odot$: $\log R = 2.25\ (\log \mu - 0.75) + 1.00$

Solar units are used throughout: $\mu = 1.98 \times 10^{33}$ grams.

Finally there is a small group of stars, which greatly surpass

[3] Proc. Amer. Phil. Soc., *in press*.

in mass those given above: Plaskett's star, Pearce's star, and the "Trumpler stars". The two former, and one of the latter (30 Canis Majoris) are spectroscopic binaries. The range of masses in this group is between 100 to 400 solar masses. It is possible that both



Spectrum-Mass Diagram
X: Spectrum
Y: Logarithm of the Mass
Small dots: individual masses of Vis. Binaries
Circled - - -: - - - - - - - - Ecl. - - -
Large - - -: mean values for Ecl. - - -

FIG. 1.—THE SPECTRUM-MASS DIAGRAM.

Plaskett's and Pearce's stars are eclipsing variables. Two of these eight massive stars are of Class B, not of Class O like most of the other massive stars of early type.

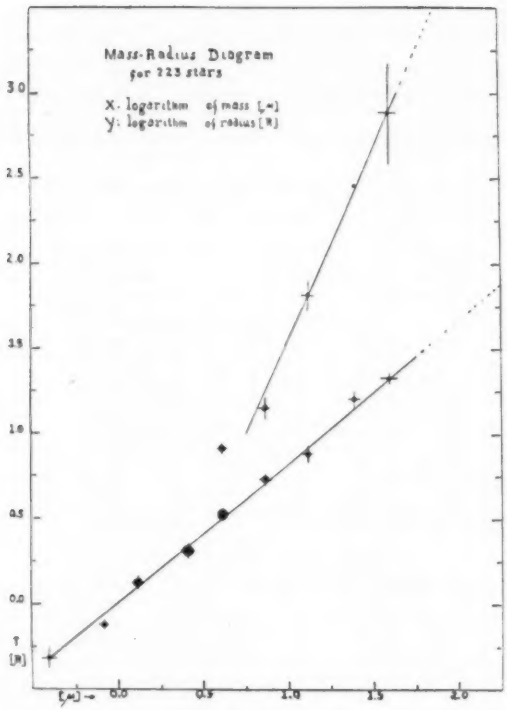


FIG. 2.—THE MASS RADIUS DIAGRAM.

SUMMARY

There exist one hundred and twenty-two single determinations of stellar mass; seventy-four from eclipsing stars, forty-one from visual binaries, and seven from the relativity theory. Indirect determinations of the masses for eclipsing systems by the writer have increased the number of individual known masses to over five hundred. From this material we conclude that the range in masses is 1 to 200; if the heaviest of the Trumpler stars is included, the range is 1 to 2000.

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THE 200-INCH TELESCOPE

By WALTER S. ADAMS*

DURING the past few years, responsibility for the construction of the 200-inch telescope and the solution of its many problems has lain with the members of three committees organized to deal with various aspects of the project. Of these committees, the Observatory Council is the executive body making final decisions upon major questions which are brought to its attention, the Policy Committee considers general matters relating to the function of the telescope and auxiliary instruments and the future operation of the Observatory, and the Construction Committee deals with all technical subjects connected with the design and construction of the telescope. Both the Policy Committee and the Construction Committee report directly to the Observatory Council.

The membership of the Observatory Council, as at present constituted, consists of representatives from the Board of Trustees and staff of the California Institute of Technology and the director of the Mount Wilson Observatory. The members of the other two committees are from the staffs of the two institutions. Dr. Max Mason is chairman of the Policy and the Construction Committees, and since the death of Dr. George E. Hale has also been chairman of the Observatory Council. Dr. John A. Anderson is the executive officer of the Observatory Council with general charge over the optical and instrument shops, and until January 1, 1939, Captain C. S. McDowell was supervising engineer in charge of construction. The advice and assistance of numerous engineers and men of science throughout the United States have been utilized to advantage on many occasions and have been given most generously.

A review of progress on the 200-inch telescope naturally divides itself into three parts: optical figuring of the 200-inch and auxiliary mirrors; design and construction of the mounting and drive; and construction and erection on Palomar Mountain.

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*Reprinted from the February 25 number of the noted English weekly scientific magazine, *Nature*.

Optical Work

The present figure of the 200-inch mirror approximates closely that of a sphere with a radius of curvature of 111 feet. The disk was first shaped on front, back, and edges by grinding with coarse carborundum and the centre was then hollowed out to a depth of about 3¾ inches with the aid, first of a 50-inch tool, and then of successively larger tools up to the full size of 200 inches. As the spherical figure was approached, finer grades of carborundum were used so that when optical tests became necessary only a few hours of polishing were needed to give the surface sufficient reflecting power. During the first stages of work upon the disk, the cylindrical holes on the back of the mirror and the large areas between the supporting ribs were filled with plaster of Paris, and after the face and back had been made parallel the 40-inch opening at the centre of the disk was closed with a glass plug weighing about one ton. The plaster of Paris was removed when the surface had reached nearly the required form, and the mirror was placed upon rubber pads which rest on the frame of the support system of multiple counter-weighted levers. The friction of these pads was required to neutralize the strong lateral pull of the grinding and polishing tools making contact over so large a surface, and for this reason the horizontal plates of the supporting system were not engaged. The optical tests, however, were made with the mirror vertical and balanced upon the support system just as it will be when in use on the telescope. Future optical work, including the parabolizing, will be carried on with the mirror resting upon the rubber pads; but these will be removed when the figuring is completed.

From the first the optical tests of the mirror proved to be most satisfactory. No change was seen in the figure when the mirror was tipped repeatedly from a horizontal to a vertical position or when it was rotated. Also no local deformations could be detected at the points of contact of the thirty-six individual lever supports. In fact, the support system was found to be performing quite as well as had been hoped by its designers. The length of the radius of curvature proved to be about two inches less than had originally been planned, but this slight difference, amounting to about one inch in the focal

length, is far within the limits allowed for in the design of the telescope, and it is probable that no attempt will be made to reduce the amount through polishing. The surface was found to be reasonably free from zones, but a small amount of astigmatism was present amounting to about 0.1 inch in the optical cut-off at the centre of curvature. This proved to be due to a slight deformation of the disk caused by the horizontal pads upon which the mirror rests, and is being corrected by a small amount of fine grinding after suitable changes in the supporting pads.

Although the final parabolic curve of the surface of the mirror will be only 0.005 in. deeper than the spherical curve, the area is so great and the process of polishing so slow that it is planned to make most of the change through fine grinding and to leave but the final stages of the figuring to the polishing tool. This procedure has already been found successful in figuring the spherical curve.

Accurate tests of the parabolic figure of the 200-inch mirror will require the use, as an auxiliary plane, of the 120-inch mirror. The completion of this mirror will be one of the next major undertakings in the optical shop. It is at present shaped on front, back, and edges, and the surface has been ground approximately flat. It is planned to figure the three auxiliary hyperbolic mirrors, one for the Cassegrainian and two for the coudé combination, by the method devised by Hindle, without the use of the 200-inch mirror. Four spherical mirrors, each about 40 inches in diameter and with a radius of curvature of 25 feet, are being prepared for this purpose, two being very nearly completed. The mirrors will be used side by side in a cloverleaf pattern and provided with adjustments for bringing their centres of curvature into accurate coincidence.

A few figures are of interest as indicating the scale of the optical work on the 200-inch mirror. About five tons of glass have been removed in the process of shaping and figuring, and about 20 tons of carborundum have been used for grinding. During the polishing about 50 pounds of rouge an hour is the average consumption with the full-sized tool, and but a small fraction of this material can be salvaged. As a result rouge has been purchased in quantities hitherto quite unfamiliar to dealers in optical supplies.

Mounting and Drive

The major portions of the telescope mounting have been under construction during the past few years at the South Philadelphia plant of the Westinghouse Electric and Manufacturing Company. They were completed and shipped in October and have been transported to Palomar Mountain, where erection has been in progress since November. These parts included the tube, the north and south members of the yoke, the two east and west members, each of which consists of three sections, which, when joined, form a 60-foot tube 10 feet in diameter, the declination bearings and the hemispherical south bearing of the polar axis with its oil pads. Several of the individual pieces weigh between 45 and 55 tons, and the total weight of the completed mounting will approximate 500 tons. The north and south bearings of the telescope are on oil films maintained under high pressure, while the declination bearings are of the ball type. At the present time the south member of the yoke has been placed in position on its bearings and the supports for the oil pads at the north end are installed in readiness to receive the section of the yoke which will form the journal supporting this end of the telescope. This feature of the mounting is a welded structure, shaped like a horseshoe, about 4 feet deep and 46 feet in diameter. It was machined with the tips of the crescent under tension so that it will have an accurate circular form when carrying the weight of the telescope.

The large gear wheels, two for the right ascension drive and one for the declination, are 14 feet 3 inches in diameter, and are being cut and ground in the Pasadena instrument shop, where all the control mechanism is under construction. The driving control of the telescope will be electric with a five per cent range in rate, and the instrument will be provided with computing devices for automatic settings in position.

Construction and Auxiliary Instruments on Palomar Mountain

The dome to house the 200-inch telescope is 137 feet in diameter and has been built and erected. The building is of double construction throughout with an air space between the two walls and heavy

insulation on the inner wall. The insulation of the steel dome is by means of aluminium foil set in panels 5 inches thick, which cover the entire interior surface including the 35-foot split shutter. It is expected that the daily temperature range within the dome will not exceed 3 degrees. The outer shell of the dome is of monocoque construction, consisting of three-eighths-inch steel plates welded together and stiffened by an interior framing of girders and arches.

The dome weighs about 1,000 tons and is mounted on thirty-two trucks with spring adjustments and forged steel wheels. The rails are welded to avoid joints and have been ground to a bevel so that the motion of the dome gives very little vibration. The driving mechanism consists of two motors, 180° apart, which operate through reduction gears to turn rubber-faced driving wheels which are held by springs against the vertical flanges of the rotating dome. This design has proved effective, and the friction of the rubber faces provides a brake against rotation of the dome, by high winds.

A travelling crane with a capacity of 60 tons is attached to the main arches of the dome, and the platform for carrying the observer to the small turret in the centre of the tube at the prime focus of the telescope will also be supported by this part of the structure. The basement of the dome will contain the large aluminizing chamber, a number of offices, photographic rooms under controlled temperature, small physical and chemical laboratories and the pier of the large coudé spectrograph room. The electrical control boards are housed on a mezzanine floor, and above this but just below the level of the telescope mounting is the main observing floor.

It is essential in the case of the 200-inch telescope, in which the field of sharp definition at the centre of the photographic plate is limited and the value of observing time is extremely high, that the observational programme be defined as accurately as possible through survey work and identification of objects with instruments having wide angular fields and great light efficiency. Two Schmidt telescopes have been planned for this purpose, one of which, with an effective aperture of 18 inches and a focal ratio of 2.0, has been in operation for about three years. It has been most productive in studies of nebulae and the discovery of supernovae. A second instru-

ment of this type, with an effective aperture of 48 inches and of focal ratio 2.5, is now under construction. The 45-foot dome has been erected on Palomar Mountain and the 72-inch pyrex disk for the spherical mirror has been received from the Corning Glass Works. The figuring and support of the 48-inch Schmidt correcting plate, which will not exceed one-half inch in thickness, will present some interesting optical and mechanical problems.

Mount Wilson Observatory,
Pasadena, California.

OBSERVATIONS OF SATURN, 1936-8

By Walter H. Haas

THE observations herein described were conducted chiefly with the ten-inch refractor of Mount Union College in Alliance, Ohio, although there were also used a six-inch reflector at New Waterford, Ohio, and the nine-inch refractor of the Case School of Applied Science in Cleveland. For observations by others, I am indebted to Hugh M. Johnson of Des Moines, Iowa; Ed. Martz of Oak Park, Illinois; Latimer J. Wilson of Nashville, Tennessee, and Wolf W. Spangenberg[1] of Germany.

It is well known among planetary observers that, when Saturn's rings are edgewise and the earth lies on the opposite side of the plane of the rings from the sun, then bright spots are seen on the rings where sunlight has penetrated through them, these spots lying at Cassini's Division and the Crape Ring, just where most sunlight can get through.[2] Now in 1936 the sun and the earth both lay north of the plane of the rings until December 29, and we should expect no such spots before that date. On June 29, however, the elevation of the earth above the plane of the rings was very small, less than 0°.002. Martz on July 1, Spangenberg on December 25, and I on July 2 saw strikingly bright spots at the cusps,[3] looking much like those produced by penetrating sunlight. Wilson and I frequently saw similar, if less striking, spots from June to September; but German observers saw no such spots during this period. Assuming that the spots are real, as the brightest ones certainly were, we can best explain them by irregularities in the thickness of the ring and in the distribution of its constituent meteoric particles. The thicker or denser portions would reflect more sunlight than the thinner and would be much brighter when the rings were edgewise. Our conclusion is supported by other observations made in June-July, 1936. Martz and I saw darker portions in the shadow of the rings on the ball, evidence of condensations of particles in the rings. Wilson and

[1] "Observations of Saturn in 1936", W. W. Spangenberg, A.A., **3**, 21, 1937.
[2] "Saturn's Rings in 1907", E. E. Barnard, Ap. J., **27**, 35, 1908.
[3] "The Rotation of Saturn's Rings", W. H. Haas, A.A., **2**, 106, 1936.

I both saw one arm of the rings thicker than the other near mid-July.

As the rings gradually became wider, I first detected the gap between the rings and the ball on September 18, 1936, when the elevation of the earth above the plane of the rings was 2°.0. Even in 1937, however, with this elevation as much as five degrees, Johnson and I could only suspect rather than see Cassini's Division; but Martz saw this mark definitely. The elevation was about ten degrees in 1938, but Johnson and I saw Cassini's Division gray and diffuse. However, I had thirty minutes of all-but-perfect seeing on October 18, 1938; and Cassini's Division then looked sharp, black, and narrow, just as on the old drawings. This observation confirms what the planetologist knows only too well: the ordinary poor seeing may greatly distort the true appearance of a mark. Encke's Division, gray and broad, was seen in Ring A on October 18.

In at least one respect Saturn looked unusual to me in 1938: Ring *A* was brighter and whiter than *B*; I observed this appearance repeatedly. All old drawings and photographs show *B* definitely brighter than *A*. Confirmation of this abnormal aspect is desired.

The Crape Ring was seen projected on the ball in 1936, in 1937, and in 1938. It was appreciably darker than any Saturnian belts but was much lighter than the shadow of the rings on the ball. With good conditions, I have twice seen it off the ball, on October 18, 1938, and on January 8, 1939; but there was so little contrast between it and the sky that it usually could not be discerned.

On September 21, 1936, at 2:28, U.T., Harley Roth, Mount Union student, while looking at Saturn in the 10-inch refractor and not having been instructed to look for any certain thing, remarked that the rings were "pale blue, like a neon sign". I immediately confirmed the hue, never having seen it before. The tint was seen several times that autumn and again in 1937. As far as I know, other observers have reported previously no blue colour on the rings; but there is evidence that it is (or perhaps was, as we shall see soon) real. It was often commented about in the autumn of 1936 by visitors to the Mount Union Observatory, who had not been told to look for it. Photographs of Saturn in red and in yellow light, taken by Martz at Griffith Observatory on June 20, 1937, show the rings darker than

the ball, blue surfaces photographing dark in red or in yellow light. Johnson saw the blue tint in 1937 before knowing of my work. Several persons at either Des Moines or at Alliance, asked merely to describe the colour of the rings, called them bluish or greenish.

It would appear that the colour varied in intensity. In September-November, 1936, the rings were sometimes pronouncedly blue and sometimes like the ball. In June-November, 1937, the hue was usually a pale bluish white but varied. For example, the colour was called yellow-white on September 24 and 27; blue tinges were remarked again on September 28 and 30. Johnson also found the colour differed from one observation to the next. In 1938 I never certainly saw any blue in a clear sky with the Case or Mount Union telescopes except late in May, when Saturn was seen on a brightening sky at a low altitude (scattered sky-light?). With the six-inch reflector, the rings seemed violet and darker than with the larger instruments.[4] Still more puzzling are changes of colour in short periods. On November 11, 1936, 0:40 U.T., the rings were deep blue and contrasted strikingly with the yellow ball. Yet at 1:04 the rings were the same colour as the ball. We feel as though an error of observation must certainly be involved, but there are other examples. On November 4, 1937, at 0:00 U.T., the rings were dull white but had become distinctly bluish by 1:00. On September 3, 1938, the rings were pronouncedly violet at 2:46 and less markedly so at 4:07.

The colour is probably to be explained by the size of the particles of the rings and the angle of incident sunlight. If the blue colour is due to Rayleigh's scattering, it signifies that the dimensions of the particles are very small, less than .000055 cm. If we assume that the blue colour was absent in 1938, we may conclude it is absent whenever either the sun or the earth is more than five degrees above the plane of the rings. If we consider the sun, we are dealing with the reflection of light from the particles; if the earth, with the concentration of particles in the line of sight. Changes in colour are attributable to variations in the size and density of distribution of the particles, for sunlight will be reflected from different parts of the ring as the particles in the ring rotate around Saturn.

[4] Johnson saw a violet hue with a five-inch reflector in 1938.

The four most conspicuous belts of Saturn in 1936 were, according to my own observations, in order the north equatorial, the south temperate, the north temperate, and the south equatorial; to be sure, the rank varied during the six months of observation. The work of Martz, Wilson, and Spangenberg would indicate that the two temperate belts should come first. Certainly these two surpassed any others in 1937, and the south temperate was the darker; a drawing by Spangenberg confirms their dominance. The only belt seen in 1938 without the greatest difficulty was the south temperate; the north temperate may have been hidden by the rings. Certainly the belts of Saturn are far less active than those of Jupiter. They are also less coloured, and yet colours are not entirely absent. On August 7, 1935, I thought one temperate belt bluish and the other reddish. In September-October, 1937, Wilson and I considered the north equatorial belt red. In 1938 I observed the south temperate belt to be reddish.

MY WORK WITH THE TELESCOPE

By DeLisle Garneau

MY beginnings in Astronomy are rather vague for it was back in 1910 that my father took me on our veranda and pointed out to me, not far from the zenith but south of it, what must have been Halley's Comet. I was then 4 years old but the sight impressed me so much that it has remained vivid in my mind to this day. It was not till 1919 that my interest in astronomy was really awakened when an uncle of mine gave me as a Christmas gift a book entitled: "Book of Wonders and Curious Things" prepared by the University Society and the Aften School of America; this book, which I still have, contains a chapter by Oliver C. Farrington on: "The Wonders of the Heavens". I had at that time a small mariner's telescope and so proceeded to see some of these "wonders". I accordingly directed my telescope out of a window in the back of our house to the constellation of Orion and feasted my eyes on its famous nebula. I was so enraptured by my first observations that I set my mind on getting my parents to purchase me a bigger and better instrument. I did not have to wait very long for my wish to be fulfilled and soon received a 2-inch refractor, my first real telescope. I then made myself a small observatory in the skylight of our house and every afternoon after school observed the sun and drew its spots; some evenings when my homework was done I would climb up a step-ladder in the attic to my observatory and scan the heavens; I remember drawing one fine winter's evening, the Pleiades.

Editor's note:

Mr. Garneau is our most diligent and enthusiastic amateur observer in the Province of Quebec. As well as being a member of our Society, he has for years been a member of the Astronomical Society of France. He makes systematic series of astronomical drawings, observes all new phenomena that are announced, and sends many drawings in to our Society. (Typical charts of the sun's disc are reproduced in the accompanying article.) Equally important is his work in popularizing astronomy among the French speaking Canadians, chiefly by very informative articles in the monthly magazine "La Revue Moderne." Mr. Garneau also systematically co-operates in the international program of auroral observations. F. S. H.

In summertime we used to go down below Quebec to a resort called Cacouria and there with my telescope and Camille Flammarion's book, "Les étoiles et les curiosités de ciel", sought to find all those beautiful double stars which he describes so enthusiastically. I thus familiarized myself with the constellations. I also made sketches of Jupiter and of its satellites and followed their configurations from night to night. Saturn's rings were at that time well opened and received my attention. I jotted down in a copy book all the double stars I had seen and had been able to separate with my telescope. In 1924 I was given a Busch refractor which

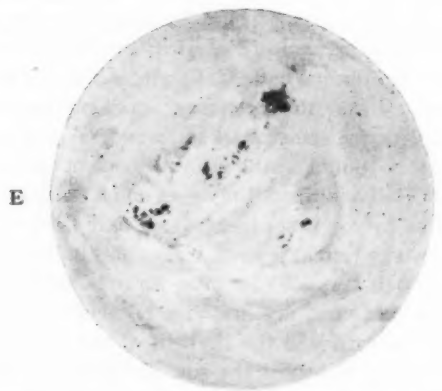

Fig. 1.—Drawing of the Sun, September 11, 1937; 9:05-10:10 a.m.

an optician said magnified, to quote his own words, "a thousand times", but on trying it on Mars which was at her favorable opposition in August of that year was greatly disappointed by the results for, although a good instrument, it was not more powerful than the one I possessed. In 1925 took place the partial eclipse of the sun. I took snapshots of it with an ordinary box-camera and had them enlarged. Later on I exchanged my two telescopes for a 3-inch altazimuth. I now own a 4-inch altazimuth Lancaster bought from Harrison & Co., Montreal. After four years of continuous observation the time came when I had to look out into the world and so to

speak come down to earth in order to complete my education preparatory to entering business.

In the latter part of 1935 I resumed my studies with the telescope but as I had only a few evenings and week-ends at my disposal my work had to be limited to the little time I could afford. On June 21st, 1936, I gazed upon a nova, then Nova Lacertae, the first one I had ever seen. It was then of about 3rd magnitude. I drew the new star and its surroundings and observed it during many evenings but alas the Peltier Comet came into view and being the first I had a chance to observe through a telescope I forsook the star which was

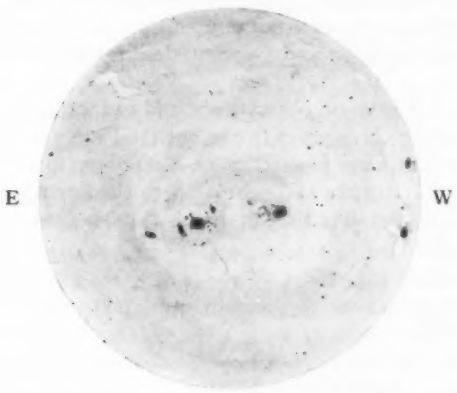

Fig. 2.—Drawing of the Sun, April 21, 1938; 9:40 to 10:20 a.m. (4-inch telescope, magnification ×50)

rapidly dimming and lost it. The comet though was still there. I had first sighted it on July 20th at 10.30 p.m. after a search of half an hour with a pair of binoculars and found it in Cassiopeia. I made many drawings and followed it until August 4.

In July, 1937, I observed the sun every day and drew it. I thought it was quite a coincidence to have struck the month when the spots were at their maximum. I was informed through a rapid information service of the Astronomical Society of France of the discovery of a new comet by Finsler. I recorded it in my diary as follows:

July 31st, 1937: "Found Finsler's Comet east of 201 Camelopardalis. It is of same magnitude as star west of her and quite visible to the naked eye. Through my telescope the nucleus of the comet appears surrounded by a round nebulosity with a short thin tail tapering off to a point."

A few evenings later I have:

Aug. 5: Comet west of 78 Draconis and more brilliant than that star. Same mag. and colour as Lambda. Its aspect is similar to that of July 31st only nucleus seems more elongated. This evening the comet occulted an 8th magnitude bluish star. Its nucleus crossed in front of the star without eclipsing it but causing a slight diminution of its light.

Since 1937 I have been keeping what I called: "Journal d'un observateur". I write down in it observations of every kind: stars, lunar occultations, Northern Lights, solar and lunar halos and coronas, barometric pressure, maximum and minimum temperatures of the day, wind direction and velocity, descriptions of sunsets, rainbows, etc.

At present I have no observatory and in fact have done all my work for the last three years in the open. I am very interested in double stars and have plotted quite a number. I intend making drawings of star clusters and nebulae with the intention of comparing them over a period of time in search of novae and variable stars.

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THE PROBLEM OF MIRA

By William A. Luby

MIRA is a long period variable with light period 331.6 ± 15 days. The light change is six or seven magnitudes and is never twice alike. Interferometer measures by Pease give a diameter of 490,000,000 kilometers. He placed the mass of Mira between one and ten times the sun's mass. The mean density for a mass of $5\odot$ is .0001 of an atmosphere. Unlike the Cepheids the maximum velocity of recession of Mira comes at maximum light and the maximum velocity of approach at light minimum. At maximum both an emission spectrum and an absorption spectrum are present. The purpose of this paper is to offer an explanation of the variable light change, the variable light period, the two types of spectra shown at maximum, and the velocity of approach and recession all based on the tidal action on Mira by a small but invisible companion.

The results in Table I are derived from the known data with a tentative use of periods P and $2P$ and of different masses between one and ten. The formula $a = \sqrt[3]{P(m_1+m_2)}$ gives the values in the third line of the table for the distance at which a particle would revolve about Mira based on the masses and periods of lines one and two of the Table. If d is the distance of the companion from the surface of Mira and r is the radius of the primary, the ratio R of the tide raising force on the near side of the primary to that on the far side is given by the formula $R = \dfrac{(2d+r)\ (d+2r)^2}{d^2(2d+3r)}$. This formula was used to obtain the results of the last line of Table I. Since Mira is of very low density the tidal deformation would be enormous and the result would be an "egg-shaped" primary.

The discussion which follows will be clearer if studied in connection with Figure 1. There the "broadside-on" positions are denoted by (b) and (d) and the "end-on" positions by (a), (c), and (e).

Joy (Mount Wilson publications No. 331) calculated on the pulsation hypothesis that a 15 per cent variation in the diameter is required to take care of the velocity variation. It is clear that the tide wave must rise high enough to explain the velocity variation but

must not reach or extend beyond the orbit of the companion. In Table I, $d=a-r$ where $r=245{,}000{,}000$ kilometers, the radius of Mira. Column 2 shows d is negative and the companion would be inside the primary. In column 4, $d=57{,}000{,}000$ kilometers. Fifteen per cent of the diameter is 73,500,000 kilometers. It may be doubted, since the two tides are so unequal, whether d of Column 4 is great enough for clearance of the companion and the wave.

It seems impossible to explain the velocity variation and the light variation with one light maximum and one light minimum in each orbital period. But, as will be seen presently, an explanation appears possible if in each orbital period there are two light maxima and two light minima.

TABLE I

P, days	331.6	331.6	331.6	633.2	663.2	663.2
M_1+m_2, $\odot=1$	5	5.5	10	5	5.5	10
a	239.6×10^6	247.3×10^6	302×10^6	380×10^6	392.6×10^6	479.2×10^6
d	-5×10^6	2×10^6	57×10^6	135×10^6	148×10^6	234×10^6
v,km/sec.			66.2	42	43.0	52.5
$m_2,\odot=1$			.08231	.0646	.0694	.1060
Tide Ratio, R			39:1	11:1	10:1	7:1

This implies an orbital period of 663.2 days or twice the period of the light variation. For this value of P the masses of columns 5, 6, and 7 and the corresponding values of a and d are admissible since the companion would then clear a tidal wave of the required height. Other values of m between 5 and 10 and even less than 5 would also be possible with $P=663.2$ days.

The low surface gravity of Mira and the tide ratio of column 6 indicate that a planetary attendant 73 times the mass of Jupiter would produce an enormous distortion of figure of the primary. The result would be an egg-shaped or a pear-shaped primary. If

such a star is viewed in various directions there would be enormous variations in the luminosity. Maximum light would come in the "broadside-on" position and minimum light in the "end-on" position. The tide wave would be composed of the dark outer material leaving a central zone bright. This would account for an absorption and an emission spectrum at light maximum. Moreover, the constriction of the central zone combined with the motion of the tide wave would give a velocity of recession.

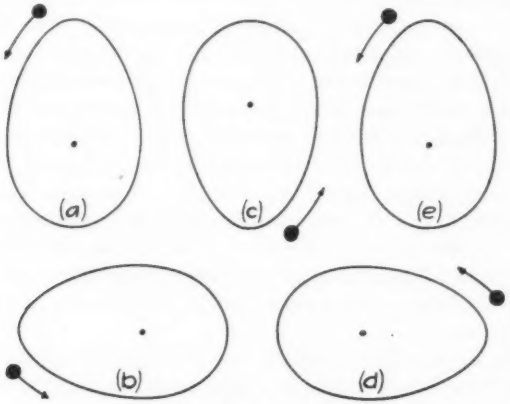


Fig. 1.—Proposed Model of Mira Ceti.

In the "end-on" position the long diameter would be pointed toward the observer, giving the maximum velocity of approach at minimum light. It appears from the value of R that the velocity of approach at two successive minima would be unequal. If a real difference does exist, it may yet be possible to derive it from the observations.

If orbital motion exists, the primary will move toward the earth at one maximum and away from the earth at the next one. This orbital motion seems to be indicated by the spectroscopic values of the velocity at maximum. Joy in the article referred to gives fourteen such velocities. Numbering these in order from the earliest and allowing for those omitted gives an average for the seven odd

numbered velocities of 66.66 km/sec. and an average for the seven even numbered velocities of 65.56 km/sec. The difference 1.1 km/sec. is in harmony with the existence of an orbital velocity of .55 km/sec.

With this velocity we may now use the momentum equation $m_1v_1=m_2v_2$ (1) to calculate the approximate mass of the companion. In column 6, $m_1+m_2=5.5\odot$. Hence $m_1=5.5-m_2$. The orbital velocity of column 6 is easily obtained from a and the period. It is 42.8 km/sec. Using $v_1=.55$ km/sec., $v_2=43$ km/sec., $m_1=5.5-m_2$, and substituting in (1) gives

$$(5.5-m_2).55=438\ m_2 \qquad (2)$$

Solving (2), $m_2=.0694\odot$ or 73 times the mass of Jupiter. The primary would thus be 81 times the mass of the secondary.

Another indication of orbital motion comes from the dates of maxima. Professor Leon Campbell of Harvard kindly supplied me with the dates of thirty-five successive maxima beginning with J. D. 2417228 and ending with J. D. 2428486. The mean period from these is 331.1 days. Taking the differences, however, and averaging the odd numbered and the even numbered ones separately gives 327.5 days and 334.5 days, respectively. This difference is also in harmony with the interpretation that an elliptic orbit is basic in the light variation.

Obviously an elliptic orbit is not a complete explanation since the orbital motion of a binary composed of two rigid bodies has a constant period. Here, however, only one body is assumed to be rigid and the other is known to be so tenuous that it can be enormously deformed by the tidal action of even a small secondary. Moreover, one tidal wave is relatively small. If the deformation of figure is great enough the centre of mass of the primary will shift continuously toward the secondary and describe a small orbit within the primary. This would cause a variation in the distance between the centers of mass of the two bodies. If the basic orbit is elliptic, the variation referred to will be superposed upon that due to the motion in an ellipse. The variation in the light period would follow. Moreover, since the distance between the two bodies at maximum would scarcely ever be twice the same, the magnitude of the light change would also vary. On the whole, however, the variation in distance has limits. Hence the variation in the light period and in

the light change would have limits also. In the long run the various phenomena would be periodic but only approximately so.

Sound principles of dynamics have here been applied to the interpretation of the fundamental data on this long period variable without change or omission of any important phenomena. There appears, as a result, a consistent explanation of the light variation and its variable period, of the light change and its variable amount, of the two types of spectra at maximum, of the velocities of approach and recession, and of the possible variations in the diameter of Mira. A like explanation would hold for other long period variables which exhibit the same fundamental phenomena. Moreover, if the position angle of the 50-foot interferometer beam at Mount Wilson could be varied sufficiently, it would be possible to detect the differences in the long diameter and the short diameter of Mira at maximum, which are indicated by the reasoning of this paper.

June, 1939,
Department of Mathematics,
University of Kansas City,
Kansas City, Missouri, U.S.A.

METEOR NEWS

Observations relating to meteors and meteorites are cordially invited.

South African Meteor Observations, April-May, 1939

Mr. Druker has continued his regular series of meteor observations in Doornfontein, South Africa. He was actually able to observe on 16 nights in April and on 18 in May (a very fine record). Some of these results were reported in the last Journal and those for the last of April and for May are summarized in the accompanying tables. The last column in Table I gives the hourly rate uncorrected for weather factor. A total of 101 meteors was observed

Table I—Meteor Observations in the Transvaal

Date (1939)	S. Afr. S.T.	Total Minutes	Weather Factor	Meteors Observed	Hourly Rate
April 27–28	11.00 — 11.30	30	6	3	6
28–29	10.55 — 11.25	30	7	3	6
29–30	11.30 — 12.00	30	7	5	10
May 30– 1	9.55 — 10.30	35	6	3	5
1– 2	9.45 — 10.30	45	5	4	5
3– 4	9.15 — 9.45	30	5	4	8
4– 5	9.30 — 10.15	45	5	6	8
5– 6	9.55 — 10.25	30	5	4	8
6– 7	10.55 — 11.40	45	6	6	8
7– 8	9.35 — 10.05	30	7	2	4
8– 9	9.10 — 9.55	45	9—2	7	9
10–11	10.35 — 11.05	30	10	3	6
11–12	9.40 — 10.10	30	9	6	12
12–13	10.20 — 10.40	20	8	1	3
13–14	10.50 — 11.20	30	8	5	10
15–16	9.25 — 10.05	30	8	4	8
16–17	9.25 — 10.25	60	9	7	7
17–18	9.50 — 10.35	45	9	6	8
18–19	8.45 — 9.35	50	9—2	7	8
19–20	8.35 — 9.40	65	9	6	6
22–23	9.45 — 10.15	30	8	3	6
23–24	9.45 — 10.55	70	8	6	5
	Totals.....	855		101	

TABLE II—Magnitude Distribution

−7	−5	−3	−2	−1	0	1	2	3	4	5	Total	Mean Mag.
1	1	3	1	3	2	8	9	22	29	22	101	2.9

TABLE III—Colour Distribution

r	o	y	yw	w	gy	g
30	13	14	6	25	8	5

in 855 minutes, an average rate of 7 per hour. The red meteors definitely predominated among those with any marked colour. The mean magnitude of the meteors observed was a little brighter than those reported last month, probably owing to the number of nights when the moon was near the full.

P. M. M.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

David Todd

On June 1, in Lynchburg, Virginia, David Todd died at the age of eighty-four. At one time astronomer in the U.S. Naval Observatory, and for many years Director of the Amherst Observatory, Professor Todd was well known as the author of several popular books on astronomy. He published many technical researches, chiefly on eclipses and orbits of members of the planetary system. He conducted seven eclipse expeditions to several parts of the world, and in particular pioneered in the development of automatic and semi-automatic equipment for the observation of solar eclipses.

John Simon Guggenheim Fellowships for Canada

An announcement has just been received from the Secretary-General of the John Simon Guggenheim Memorial Foundation, of New York, that the well-known Guggenheim Fellowships have been extended to Canada and Newfoundland. Canadians will rejoice that these generous grants towards the advancement and diffusion of knowledge will each year encourage and permit six Canadians to undertake investigations which would otherwise be financially impossible. In part the statement of the conditions of award of the Fellowships reads as follows:

> Announcement is made that the Fellowships of the John Simon Guggenheim Memorial Foundation have been extended to Canada and Newfoundland. These Fellowships were established in 1925 by former United States Senator and Mrs. Simon Guggenheim, in memory of a son, John Simon Guggenheim. By them, during the past 15 years, 840 American and Latin American artists, poets, novelists, composers of music, biologists, physicists, economists and workers in all fields of the mind and spirit have been assisted, and now six stipends, normally fixed at $2,500 a year, will be awarded annually to assist scholars and artists from Canada and Newfoundland to come to United States to do research and creative work in their various fields.
>
> The Guggenheim Fellowships are awarded to men and women, married or unmarried, of every class and creed, on equal terms. They are not for beginners in the arts and scholarship but for workers who have already demonstrated their capacities. Normally the ages of the Fellows are between 25 and 40 years and the average age of the Fellows appointed in the United States is thirty-six years.

The previous production of work of the highest quality is a prerequisite to appointment to a Guggenheim Fellowship. The Fellows are appointed solely on the basis of the quality of their accomplishments, past and prospective, with no thought of distributing Fellowships by fields of work, by colleges or universities, or with regard to any factor extraneous to the question of quality.

The John Simon Guggenheim Memorial Foundation has a capital fund of more than seven million dollars, all donated by Senator and Mrs. Guggenheim. All of the Foundation's income is devoted to providing opportunities for men and women of the highest ability to further their work, and the assistance is available, within the limits of the Foundation's income, to scholars working in any field of knowledge and to artists working in any branch of the arts. The Fellowships granted Canadians will be tenable in the United States.

Centenary of Pulkova Observatory

On August 19, 1839, the Imperial Observatory at Pulkova, Russia, a few miles outside St. Petersburg (now Leningrad), was completed. Friederich Georg Wilhelm Struve was its first director. The chief instrument was a fifteen-inch refractor, long the largest telescope in the world. During succeeding years a thirty-inch refractor, instruments of position, photographic telescopes, and many pieces of auxilliary apparatus were added. This national observatory at Pulkova, with branches established later at Nicolaieff and Simeis (Crimea), has added great catalogues of positions and motions of the stars, and many volumes of varied researches, and has served in influencing the astronomical careers of many of the Russian astronomers during the past century. It is understood that the centenary is to be suitably observed in the Soviet Union.

Two New Comets

Cablegrams to the Harvard Observatory (Announcement Cards 495 and 496) report the discovery of two new comets by European observers.

Comet Rigollet	Comet Kaminsky
1939 July 28. 0868	1939 July 24 22^h $00^m.0$
R.A. 4^h $54^m.0$	*R.A.* 20^h $55^m.0$
Dec. +25° 45′	*Dec.* −07° 00′
Magnitude 8	*Magnitude* 7
Daily motion: 4° NE.	*Daily motion*: 4° S, 5^m E

In each case the object is described as having a nucleus, but no tail is mentioned.

The Dresden Meteorite

On Tuesday night, July 11, a very bright meteor crossed south western Ontario, and was seen by large numbers of people in Middlesex, Elgin, Huron, Bruce and Kent counties. Several small scattered pieces of meteorite, and one large eighty-eight pound body were recovered near Dresden, Ontario. As this is the first major recovery of a meteorite whose flight has been observed in this country for many years, it is of great scientific interest and importance. A detailed illustrated discussion of this object will appear in the September number of the Journal.

F. S. H.

An Airplane Hits the Lick Observatory

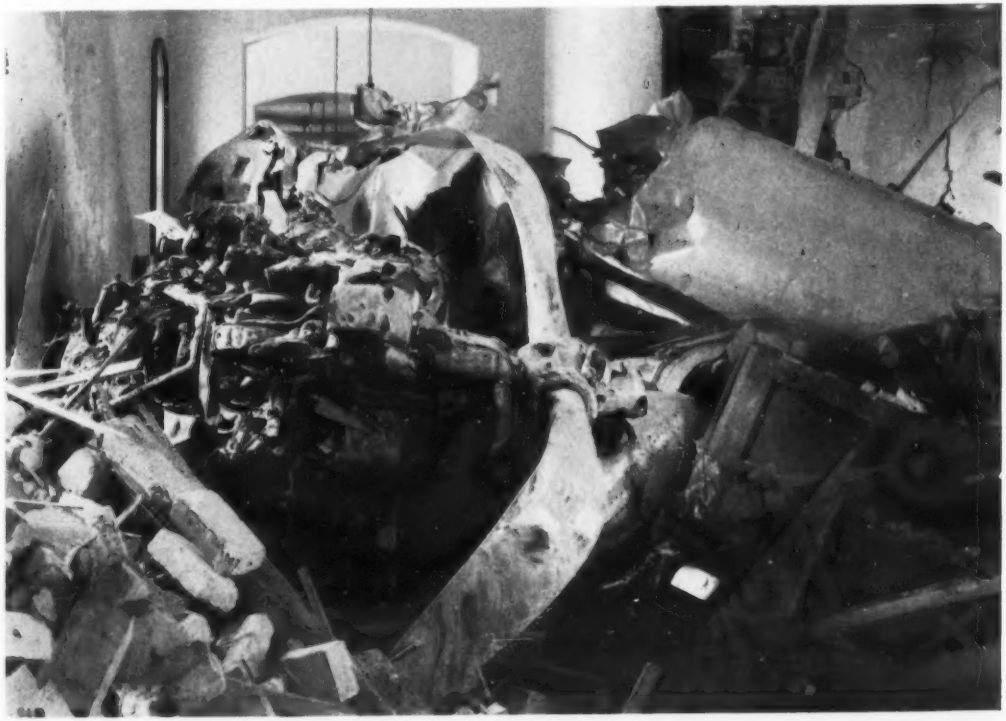
(with Plates IX and X)

On Sunday, May 21, about seven o'clock in the evening, a U.S. Army airplane hit the main building of the Lick Observatory on Mt. Hamilton, California. The building houses the great refractor, the library, and offices. The exact time of the impact was $7^h\ 10^m\ 59^s$, Pacific Standard Time, as registered on the observatory seismograph. A heavy fog hung over Mt. Hamilton at the time, and the visibility was only two hundred feet. The two fliers in the plane could have seen the observatory only a fraction of a second before the crash. Both were instantly killed.

By great good fortune, none of the Lick astronomers was in the path of the plane. Dr. Paddock and Mr. Mowbray were in other parts of the building and Miss Adams had just left by the rear door. The people on the mountain top heard the sound of a plane flying very low, and then a dull thud. They did not at once realize that it had hit the building, but thought that it had crashed on the mountain side itself. When they rushed to the front of the building, however, an amazing sight awaited them. The airplane had almost disappeared inside the building, with only the wreckage of the right wing left hanging out. The plane struck a few feet to the left of the main entrance, reducing the office of Dr. Moore and the assembly room to a mass of bricks and wreckage. The accompanying plates give an idea of the shambles which resulted. Even after the crash there

AN AIRPLANE HITS LICK OBSERVATORY—OUTSIDE VIEW.

Journal, Royal Astronomical Society of Canada, 1939.



AN AIRPLANE HITS LICK OBSERVATORY—INSIDE MAIN CORRIDOR.

was serious hazard to the astronomers as the wreckage was drenched in gasoline.

Fortunately very little of scientific value to the observatory was destroyed in the accident. If the plane had been flying a few feet further south and crashed into the great refractor, the damage would have been really irreparable. The actual financial loss of the observatory is covered by insurance. The Army sent its men and trucks, and in three days the debris was cleared away. The writer visited the observatory two weeks after the accident. From the outside of the building one sees a canvas covering the hole in the wall; inside, the damaged parts have been boarded off and the work of reconstruction begun. An account of the incident by Dr. W. H. Wright, Director of the Lick Observatory, will appear in the Publications of the Astronomical Society of the Pacific and in Scientific Monthly.

H.S.H.

THE GOOSE LAKE METEORITE

A great siderite weighing 2,573 pounds to be known as the Goose Lake Meteorite was recovered May 5, 1939, from the lava beds in northeastern California. Since it was found in a National Forest it will become the property of the Smithsonian Institution, Washington, D.C.

It was brought to the Chabot Observatory, Oakland, California, by Professor Earle G. Linsley, a member of the Royal Astronomical Society of Canada, who helped in recovering it. It has been on exhibition for a week at Chabot Observaotry and for the duration of the Exposition will be on exhibition in the Astronomical exhibit, Science Building, Treasure Island, San Francisco Bay.

It is the largest meteorite yet found in California and one of the large meteorites of the United States.

EARLE G. LINSLEY

MEETINGS OF THE SOCIETY

AT VICTORIA

March 1, 1939.—A regular meeting was held at 8.10 p.m. in the Y.W.C.A. with the president, Mr. R. Peters, in the chair.

Mr. K. O. Wright spoke briefly on the current phenomena of the sky, particularly noting the interesting occultation of Spica by the moon to occur March 8th.

Dr. McKellar then introduced the speaker of the evening, Professor H. D. Smith, who had chosen as his topic, "Some Recent Developments in the Low Temperature Field". Dr. Smith explained how Faraday succeeded in liquefying various gases and obtaining temperatures of –110° F. In our own time by obtaining lower and lower temperatures, argon, then hydrogen were liquefied; in fact, all gases except helium had been liquefied. Then in 1908 a Hollander was able to liquefy helium at a temperature of 4° above absolute zero. Since that date it has been possible, by reducing pressure, to come within 1° of absolute zero.

Dr. Smith pointed out many interesting properties of various substances when subjected to temperatures near absolute zero, and noted that many bacteria cannot be killed at these low temperatures.

Development of the uses of "dry ice" were discussed, and samples of this substance, solid carbon dioxide, were passed around the audience. Interesting slides were presented to show the manufacture of, and experiments with, dry ice.

A hearty vote of thanks was tendered to Dr. Smith. The meeting was declared adjourned at 10.10 p.m.

March 22, 1939.—A regular meeting was held in the Y.W.C.A. The meeting came to order at 8.05 p.m. with the president, Mr. R. Peters, in the chair. Two new members, Mrs. H. E. G. Newcomen and Mrs. Helen A. Hazelwood, were welcomed to the society.

Mr. K. O. Wright noted current astronomical phenomena, the chief events of the past month being the discovery of two new comets: one, a periodic comet of magnitude 15, and the other, really a rediscovery at Lick Observatory. The return quiz contest proved to be both entertaining and educational when Miss Dorothy Humeston on behalf of the junior members, questioned the president and the two past-presidents, Mr. G. Shaw and Mr. H. Boyd-Brydon.

The president next introduced the speaker of the evening, Dr. W. E. Harper, who recounted many of his experiences while abroad recently. Mr. Shaw, scheduled to speak this evening, had postponed his talk to be one of the summer series.

After a brief introduction, the entire travelogue was illustrated with a series of excellent slides. First across Canada to Ottawa for meetings of the

American Association for the Advancement of Science, where Dr. Harper read several papers, then on to London, his headquarters for some time. Pictures, both oral and photographic, of Trafalgar Square, Nelson's Monument, The Houses of Parliament, Westminster Abbey, The Tower and the Beefeaters, Greenwich Observatory and many other places of interest, were presented. The speaker noted in particular the absence of impatience and confusion during a visit to Buckingham Palace. Many places of historic interest in England were next visited—Windsor Castle, Stratford-on-Avon, Oxford and Cambridge, and others. The speaker then journeyed on to Glasgow where the audience was treated to pictures of the Fair, in particular, the Dominion of Canada exhibit. After a trip through Scotland, Dr. Harper went on to Sweden and a brief description of a dinner in the Gold Room of the Civic Auditorium at Stockholm, also meetings of the International Astronomical Union here. In closing, Dr. Harper paid a tribute to the courtesy of the Canadian National Railways agents abroad.

On behalf of the members, Dr. Pearce expressed appreciation of the return of good health to Dr. Harper. The audience concurred heartily in the vote of thanks moved by Dr. Pearce.

Meeting was declared adjourned at 9.50 p.m.

PHOEBE RIDDLE, *Recorder.*

AT TORONTO

April 4, 1939.—The regular meeting of the Royal Astronomical Society of Canada, Toronto Centre, was held in the McLennan Laboratory, University of Toronto, on April 4, 1939. Mr. S. C. Brown was in the chair.

Mr. Duncalfe gave a brief talk. Of particular interest were his remarks about the origin of the direction of motion of the hands of a clock. He pointed out that in the sundial there is no question of direction of the numbers, for the shadow of the gnomon moves from left to right during the day. This motion was carried over to the dials of clocks and watches.

The feature of the evening was "More Movies, Astronomical and Otherwise", presented by Mr. R. H. Combs. The first reel was "A Trip to the Moon." This was a very graphic interpretation of a radium-operated rocket getting out of the earth's gravitational field and so able to approach the moon. The second reel was entirely in colour and was indeed beautiful. Two of the fast stream-lined trains were shown. The new San Francisco-Oakland Bay Bridge and Golden Gate Bridge were particularly interesting. The flowers in California, Victoria, B.C., and around Mr. Combs' own summer home were colourful. Waterfalls in Oregon and in the Canadian Rockies were very beautiful. The whole reel was arranged to take us on a most interesting trip through the states, up through the Canadian Rockies and back to Ontario to Mr. Combs' summer home.

Dr. Millman dealt with a recent paper on meteoric matter of space, by Dr. Whipple. The results presented in this paper mark the beginning of high

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accuracy in this field of research. Although visual observations are best for faint meteors, observations obtained by simultaneous photographs from two stations give much more accurate results for bright meteors. By having one of the cameras fitted with a rotating shutter the speed of the meteor as well as its position can be determined. By extrapolation the orbit of the meteor around the sun is obtained. The observations agree with a rise in atmospheric temperature to 370°A. at a height of 60 km., with a subsequent drop to 180°A. at 82 km. in the auroral region, and a rise to over 350°A. at a height of 110 km. They also corroborate the view of the absence of hydrogen and helium in the upper atmosphere. Dr. Millman concluded by offering to supply information and maps to any interested in meteor observing.

April 18, 1939.—The regular meeting of the Royal Astronomical Society of Canada, Toronto Centre, was held on April 18, 1939, in the McLennan Laboratory, University of Toronto. Mr. E. J. A. Kennedy presided in the absence of the Chairman, Mr. S. C. Brown, who was unable to officiate due to an unfortunate accident to his eyes.

Mr. F. E. Braucht, 8 Kathleen Street, Guelph, Ontario, was nominated and elected to membership in the Toronto Centre. This change in the usual procedure was made since this meeting was the last formal meeting of the season.

The speaker of the evening was Dr. D. W. Best. His subject was "Some Surprising Stars". Dr. Best first pointed out that the facts that were very surprising to the early astronomers seem quite commonplace to us, since we have become accustomed to them. Perhaps the earliest discovery of a surprising nature was that the moon is a small body with no heat or light of its own; whereas the sun is at a great distance and is enormously large and hot. Dr. Best discussed the facts known about the sun in considerable detail, since the sun is an average star and the important things known of the sun can be taken as true of the stars generally. There are, however, surprising differences among the stars. These differences are mainly in volume, density, temperature, and candle power, but not mass, since most of the stars contain about the same amount of matter—from one-quarter to ten times the mass of the sun.

Probably the first known naked-eye double is the pair Mizar and Alcor. Mizar is itself double and is the first double star to have been discovered with a telescope. Later it was found that both members of this double were spectroscopic binaries, and that Alcor was also a spectroscopic binary. Thus there are actually six stars in this system. Sirius is another interesting star. It belongs to the Ursa Major moving cluster. From a study of the proper motion of Sirius it was found that it has a dark companion. The combined mass is 3.5 times that of the sun. Sirius A is 3 to 10 thousand times the brightness of B but only 2.5 times as heavy. Antares has a diameter some 500 times that of the sun, and a mass only twenty times the mass of the sun. Thus the average density of Antares is the density of a good vacuum. The largest

star known at present is the eclipsing companion of ϵ Aurigae. This star was found at Yerkes Observatory.

Dr. Best next discussed variable stars and told how the Cepheid variables can be used to measure distances. It is found that the external galaxies occur mostly in groups or clusters. Each group may be termed a super-galaxy. Dr. Best concluded by suggesting that there may be groups of super-galaxies of the second order and so on as far as the mind wishes to go.

After giving the details of the annular eclipse of the sun occurring on April 19, 1939, Dr. Millman then spoke on "Astronomical Highlights and Sidelights"; this being the final lecture of his series. Dr. Millman gave us some very lucid examples as told by students on examination. Dr. Millman showed slides to give the members some idea of general working conditions at the David Dunlap Observatory. He then discussed the work that is going on at the Observatory. The radial velocity programme of 500 stars is very nearly completed. It is gratifying to find that there are no serious systematic errors in these velocities as against velocities determined at other observatories. Dr. Young is fashioning a Schmidt camera of aperture ratio F/1, to be used behind the prism of the spectrograph to photograph faint objects. Considerable work has been done by Dr. Heard in following the light and spectrum variations in γ Cassiopeiae. Mars has been studied spectroscopically by Dr. Millman to find the differences in radiation reflected from the green areas as compared with that reflected from the desert regions. Mrs. Hogg has collected all the literature on variables in globular clusters. This will be printed as an Observatory publication. Dr. Millman then showed slides showing the observatory and telescope under unusual conditions of lighting.

The outdoor meeting of the Toronto Centre will be announced later. The meeting then adjourned.

RUTH J. NORTHCOTT, *Recorder.*

AT EDMONTON

January 12, 1939.—Mr. M. J. Hilton spoke on "Eclipses", pointing out the interest and importance of eclipses and the combination of circumstances that enables us to see them as often as we do. He described the regular cycles of eclipses and the phenomena observed during them, including the measurements made to verify Einstein's theory of the bending of light in the Sun's gravitational field. In conclusion, the speaker gave an interesting account of the eclipse expedition of 1908, Jan. 3, to Flint Island, 400 miles from Tahiti. This only just missed being a total failure, owing to cloud.

February 9, 1939.—Dr. A. J. Cook gave a detailed review of a new popular book "Astronomy for the Millions" by van den Bergh, recently purchased for the library of the Centre. After commenting not very favourably on the plates and diagrams, Dr. Cook read some extracts from the book to illustrate the author's vivid style of writing, exemplified for instance in the imaginary diary of a visitor to Mars. He pointed out that in several places the author treated

scientific hypothesis as undoubted fact. Popularization is necessarily somewhat dogmatic, but there is danger in over-simplification. The ideal book on popular astronomy would not be merely for fireside enjoyment, but should stimulate people to get out and make simple astronomical observations of their own.

March 9, 1939.—Dr. J. A. Allan, of the Department of Geology, spoke on "Meteorites". Commencing with a brief discussion of the origin and probable age of the earth, he described the appearance and character of the meteorites of which, according to some theories, the earth is largely composed. He pointed out that incandescence usually commences at a height of some 100 miles above the ground and that one meteorite may explode into a shower covering several miles.

Dr. Allan mentioned the characteristic features (with typical examples) of siderites, siderolites and aerolites, describing in particular the Widmanstätten figures which are seen when a section of an iron meteorite is polished and etched. He discussed the crater-like depressions found in Arizona, Carolina, Persia, Japan, etc., attributed to meteorites, and pointed out that in spite of long-continued drillings no large iron mass had been found beneath the Arizona crater.

Finally the speaker exhibited the "Edmonton meteorite" which he was then engaged in examining. This was a true iron meteorite, some 30 lb. in weight, which fell on the outskirts of the city of Edmonton. Details of this meteorite will be published elsewhere.

April 13, 1939.—Dr. Campbell spoke on the annular eclipse of the sun on April 19th, visible here as a partial eclipse. He described in detail a graphical method, based on that of Dupuis, for calculating the times of beginning and ending. From the data on right ascension and declination of the sun and moon, as published in the Ephemeris, and from corrections depending on the local geocentric latitude, a diagram can be constructed giving the differences of right ascension and declination, and the required times can then easily be read off.

As a postscript to this report I may add that the weather on the morning of the 19th was favourable, and most of our members must have seen an eclipse about two-thirds total.

May 11, 1939.—Mr. A. A. Gibb spoke on "Mars". After recalling the mythology associated with the planet, he described its orbit and physical characteristics, particularly the telescopic appearance of reddish background, blue-green patches, white polar caps, and the straight line and dot markings observed by Schiaparelli and Lowell.

The speaker dwelt at some length on the possibility of life on Mars, pointing out that the temperature and atmospheric conditions were not unfavourable. The rather fanciful speculations of Lowell, and the question of the objective reality of the markings were discussed. The speaker mentioned that the smaller gravity on Mars would permit of larger animals than on the earth,

if constructed of similar flesh and bone. Even if intelligent Martians exist, it would seem unlikely that their mental processes would permit of a common plane of understanding with ourselves.

E. S. KEEPING,
Honorary Secretary.

AT MONTREAL

November 10, 1938.—The Annual Meeting was held in the Macdonald Physics Laboratory at 8.30 p.m. Mr. H. F. Hall was in the chair.

The speaker, Prof. N. B. MacLean, D.S.O., Ph.D., gave a very fine account of the life and scientific work of Sir Isaac Newton, 1642-1727, illustrating his lecture with slides of Newton, of Woolsthorpe Manor which the speaker had visited and of the monuments in Grantham, Trinity College, Cambridge, and Westminster Abbey.

Dr. W. W. Francis exhibited first editions of the Principia, the Optiks and the optical lectures of Newton, taken from the Osler Library.

December 9, 1938.—The second meeting was held in the Macdonald Physics Laboratory, at 8.30 p.m. The president, Mr. E. Russell Paterson, in the chair.

New member elected—Mr. John B. Starkey.

The first speaker was Dr. W. D. Lighthall, who presented newly found data on Mayan chronology based upon positions of planets near the Sun in the year B.C. 3373. In his opinion the Diffusion Theory, that is that the civilization in Central America had its origin in Asia or the Pacific seaboard, is settled by these astronomical considerations. His full paper is to be found in the JOURNAL R.A.S.C., Jan., 1939.

The second speaker was Professor J. S. Foster, F.R.S., who gave a brief explanation of the principles underlying the Cyclotron and an outline of the relevant problems in atomic physics and in regard to its value as a chemical tracer in biological problems and in treatment of abnormal physical structures in animals. This led to a keen discussion and Dr. Foster replied to many questions.

February 9, 1939.—The third meeting of the Montreal Centre was held in the Macdonald Physics Laboratory, 8.15 p.m., with the president in the chair.

The lecturer was Professor W. D. Woodhead, Head of the Department of Classics at McGill University. His subject was The Mythology of the Constellations. This lecture will appear in the JOURNAL, R.A.S.C.

A good representative audience greatly appreciated this scholarly and humourous account of the Greek legends associated with the constellation figures.

March 9, 1939.—The fourth meeting was held in the Macdonald Physics Laboratory, 8.30 p.m. The vice-president, Mr. F. DeKinder, was in the chair.

The lecturer was Mr. R. M. Motherwell of the staff of the Dominion

Observatory, Ottawa. Subject—the 200-inch telescope. Mr. Motherwell gave a very interesting and detailed account of the making of the mirror disc at Corning, N.Y., the engineering problems involved, the figuring of the surface in California; and the design and construction of the great mounting by Westinghouse Electric and Manufacturing Company. Very fine slides were shown, especially the draughtsman's beautiful representations of the finished telescope as it will be in the course of the next year or two on Mt. Palomar, California. New features were described such as the 10-ft. hollow tube supports with steps inside and optical arrangement for bringing the light out through the declination axis; the 6-ft. circular chamber on the main axis of the telescope in which the observer may be stationed to investigate the image at the principal focus.

A. Vibert Douglas, *Secretary.*

The Royal Astronomical Society of Canada

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